Scenario-Based Assessment of Sensors for the Canadian Recognized Maritime Picture

Steve Doré
Defence R&D Canada - Operations Research Division
101 Colonel By Drive
Ottawa, ON, Canada, K1A 0K2
Tel: 613-992-4478 Email: sdore@ora.dnd.ca

Chris Helleur
Defence R&D Canada –Ottawa
3701 Carling Ave.
Ottawa, ON, Canada, K1A 0K2
Tel: 613-998-2395 Email: chris.helleur@dreo.dnd.ca

C.W. Van Fong
Defence R&D Canada - Operations Research Division
101 Colonel By Drive
Ottawa, ON, Canada, K1A 0K2
Tel: 613-992-4584 Email: fong@ora.dnd.ca

ABSTRACT

In the area of command and control projects where a surveillance sensor is being evaluated, project sponsors ask scientists to measure the operational utility and value of the sensor in order to assist in the decision making process. This paper puts forward a formal and consistent methodology of relating trial results to operational value-added by employing the Canadian Forces Force Planning Scenarios. The approach was applied within an Operational Evaluation (OPVAL) of a High Frequency Surface Wave Radar (HFSWR) system that is used for over the horizon coastal surveillance. The results of this OPVAL were assessed to determine HFSWR's contribution to surveillance-based Force Planning Scenarios. The primary contribution of this paper is to demonstrate the feasibility of relating OPVAL results directly to the scenarios in a quantifiable fashion. The main conclusion of the paper is that the approach presents the capabilities of the sensor system to the decision makers in a logical and intuitive way and provides a context to the results of the analysis that is easy to communicate to a larger audience.

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE **SEP 2002**	2. REPORT TYPE	3. DATES COVERED **00-00-2002 to 00-00-2002**

4. TITLE AND SUBTITLE **Scenario-Based Assessment of Sensors for the Canadian Recognized Maritime Picture**	5a. CONTRACT NUMBER 5b. GRANT NUMBER 5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER 5e. TASK NUMBER 5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Defence R&D Canada ,Operations Research Division,101 Colonel By Drive,Ottawa, ON, Canada, K1A 0K2, ,**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR’S ACRONYM(S) 11. SPONSOR/MONITOR’S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES
The original document contains color images.

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			
unclassified	**unclassified**	**unclassified**		**14**	

1. INTRODUCTION

The Recognized Maritime Picture (RMP) is defined as a composite picture of activity of a maritime area of interest for a given time. An RMP requires timely input from many data sources to determine the location, identity, and activity of targets of interest, in order to provide sufficient information to decision makers. A number of civilian, military, and allied sensor systems contribute to the development of an RMP. These systems include automatic self-reporting positional systems, air surveillance, over-the–horizon radar, electronic intelligence, space-based radar, and high frequency direction finding sensors. The costs of developing/acquiring new sensors (or even including sensor reports from our allies or other government departments) can be high. Accordingly, decision makers require a solid basis upon which to evaluate potential sensors prior to making sensor procurement or development decisions.

In the area of command and control projects where a surveillance sensor is being evaluated, project sponsors often ask scientists to measure the operationally utility of the sensor in order to provide justification for buying one sensor suite over another. Traditionally, defence scientists employ Measures of Performance/Effectiveness (MOP/MOEs) to determine the value-added provided by the sensor [Dickinson *et al.*, 1997].

The authors have adopted a more formal and consistent methodology of evaluating projects to gain acceptance by sponsors and stakeholders and thereby improve the decision making process. This approach employs the Canadian Forces Force Planning Scenarios (FPS), which are based on the tasks and roles identified in the 1994 Defence White Paper [National Defence, 1994]. These scenarios are representative of the generic types of missions that the CF has been called upon to perform. Basing evaluation decisions on these scenarios authenticates the evaluation process and improves the odds that the right sensor is purchased for the right reasons.

The following approach was taken for the Operational Evaluation (OPVAL) of a new Canadian High Frequency Surface Wave Radar (HFSWR) system. First, the scenarios that relate to the operational role of HFSWR were identified (e.g. Search and Rescue, Surveillance). Second, representative vignettes were developed for each of the selected scenarios (e.g. a vessel in distress, contraband carrying vessel entering Canadian waters). Third, MOP were devised for each vignette (e.g. positional accuracy, number of reports). Fourth, quantifiable "value-added benefits" were developed for each vignette (e.g. improved positional accuracy and accurate continuous tracking are very desirable benefits that a sensor can provide to SAR and Surveillance scenarios respectively). Fifth, trial data from the HFSWR OPVAL was used to determine whether HFSWR could provide these value-added benefits, and to what extent.

The authors demonstrate both the utility and drawbacks of this approach in assessing surveillance sensors. This is done using OPVAL trial results from the HFSWR system located at Cape Race, Newfoundland. Independent "ground-truth" was obtained on a cooperative controlled ship. The HFSWR data was assessed for its contribution to the RMP, both individually and collectively (as fused data), given the requirements of the FPS vignette.

2. HF SURFACE WAVE RADAR SYSTEM (HFSWR)

The following section describes the HFSWR system and discusses an OPVAL trial that was conducted in Jan 2002. The results of this OPVAL are used as input into this Scenario-Based Assessment and will be presented in Section 3.

2.1 HFSWR TRACKS

HFSWR is a potential data source that is being seriously considered for acquisition by the Department of National Defence (DND). HF surface waves propagate along the ocean surface and, because of diffraction, follow the curvature of the earth. HFSWR can achieve long ranges due to low attenuation rates of vertically polarized HF electro-magnetic signals when propagated over the conductive ocean surface. There are presently two HFSWR sites located in Newfoundland, one at Cape Race and the other at Cape Bonavista, that are being used to demonstrate the capability of the HFSWR technology [Moutray and Ponsford, 1997]. The system employs an array of antennas with coherent receivers at the output of the antenna elements. The signal is sampled and the required filtering, beam forming, Doppler analysis, tracking, noise suppression and other signal processing operations are performed. In order not to overload the command and control system with false detections, only the output of the tracker is sent for inclusion in the RMP.

The HFSWR system is being considered for surveillance out to the 200 NM Exclusive Economic Zone (EEZ). The system provides a number of advantages relative to other wide area maritime surveillance systems: it is relatively inexpensive to install and operate, it operates virtually continuously, and the tracker output provides near-real time vessel position, course, and speed. On the other hand, HFSWR must operate in a congested signal spectrum with limited signal bandwidth, in the presence of sea clutter, ionospheric interference and both external and man-made noise.

The HFSWR tracker is currently optimized for non-manoeuvring targets since transiting vessels will maintain a straight course, or leg, for long periods of time. The majority of the vessels in the area of interest will maintain a time-on-leg (TOL) of greater than 4 hours. However, the tracker tends to produce broken tracks with unique identification numbers when the vessel is manoeuvring. An example of a Canadian Patrol Frigate being tracked during a trial at relatively close range is shown in Figure 1. Each time the vessel turns the tracker initiates a new track and assigns a new track identification number.

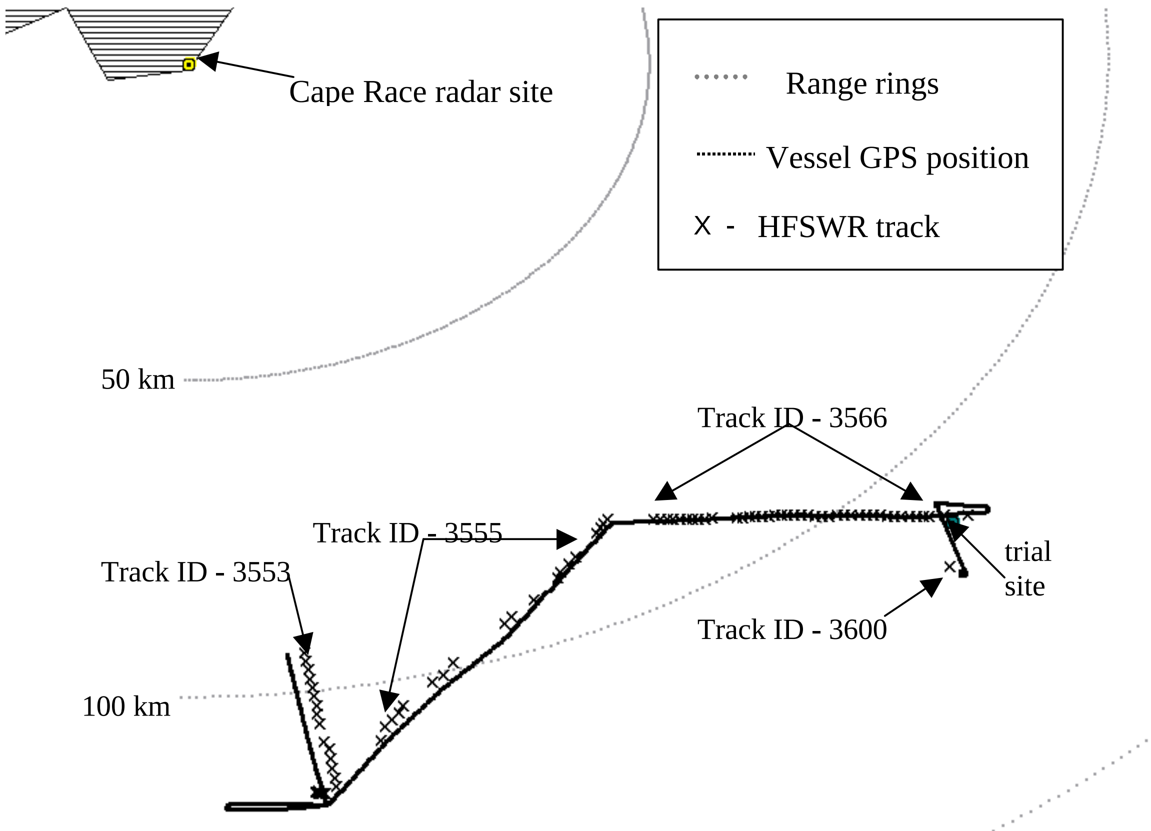

FIGURE 1: HFSWR TRACKING OF VESSEL FROM CAPE RACE SITE WITH GROUND TRUTH

Existing data fusion software (e.g. [Lefebvre *et al*, 2001] and [Simard *et al, 2000*]) provides a capability that will associate track segments if the manoeuvre is not very abrupt and when other data sources provide track-to-track fusion potential. This type of software works well for transiting vessels making corrections to their course but is ineffective when the vessel is manoeuvring abruptly and frequently. Fishing vessels, which may have small radar cross-sectional area, are constantly manoeuvring while fishing, thereby resulting in low average time-on-leg values. As a result they often produce broken tracks.

The decision to acquire the system is based on the results of an OPVAL that determines the value-added utility of HFSWR to the RMP. The evaluation process is further complicated by the fact that any data source must be interoperable with other surveillance systems to generate an RMP.

2.2 HFSWR OPVAL TRIAL

Controlled Ship Trial Jan 4-7, 2002

A trial involving a controlled ship was conducted within the nominal coverage region of the HFSWR system situated at Cape Race, Newfoundland. Data was collected from HFSWR and compared against the position of the ship as it followed its pre-determined route. Members of the crew manually recorded ship positional data at a minimum of every 15 minutes throughout the 60-hour trial.

Seven Measures of Performance (MOP) concepts were used to assess the HFSWR performance. A brief description of these is provided in Table I.

TABLE I: RELEVANT MOP CONCEPTS FOR AN ISR SYSTEM EVALUATION

MOP	Description
Number of Reports:	The total number of individual detections from a surveillance source, which contribute to building up the RMP.
Positional Accuracy:	The distance between the actual position and that reported by the sensor at a given time.
Track Ambiguity:	The ability of a source to provide information that rules out and/or helps to identify a vessel of interest. The longer a system is able to maintain the same track ID number, the lower the track ambiguity. Conversely, the more different track ID numbers associated with one vessel, the higher the track ambiguity.
Timeliness:	This considers of two main variables: first, the period of time between successive contact reports and second, the time between the initiation of a contact report and its arrival into the RMP.
Coverage:	The area within which the system can make reports on vessels.
Sensitivity:	The ability of the surveillance source to pick up changes in direction and speed of vessels tracked and its ability to detect and track small vessels.
Uniqueness and Complementarity:	This assesses the ability of the system to provide value when working together with other sensors (e.g. the existing RMP sensors). Uniqueness describes the condition where a target vessel is detected by only one sensor, whereas Complementarity describes the condition where more than one sensor is in contact with the vessel (the mathematical complement of the number of unique contacts).

Assessment of HFSWR Performance

Extensive analysis was performed on the data that was collected from this 60 hour OPVAL trial though only the salient results are presented here. Note in Figure 2, that HFSWR tracking is shown in shades of blue while the ground truthed track of the ship for all ten legs is marked with grey circles. For the first six legs of the route, positional updates of the ship were provided every 15 minutes. For legs 7 through 10 inclusive, these updates were performed every five minutes.

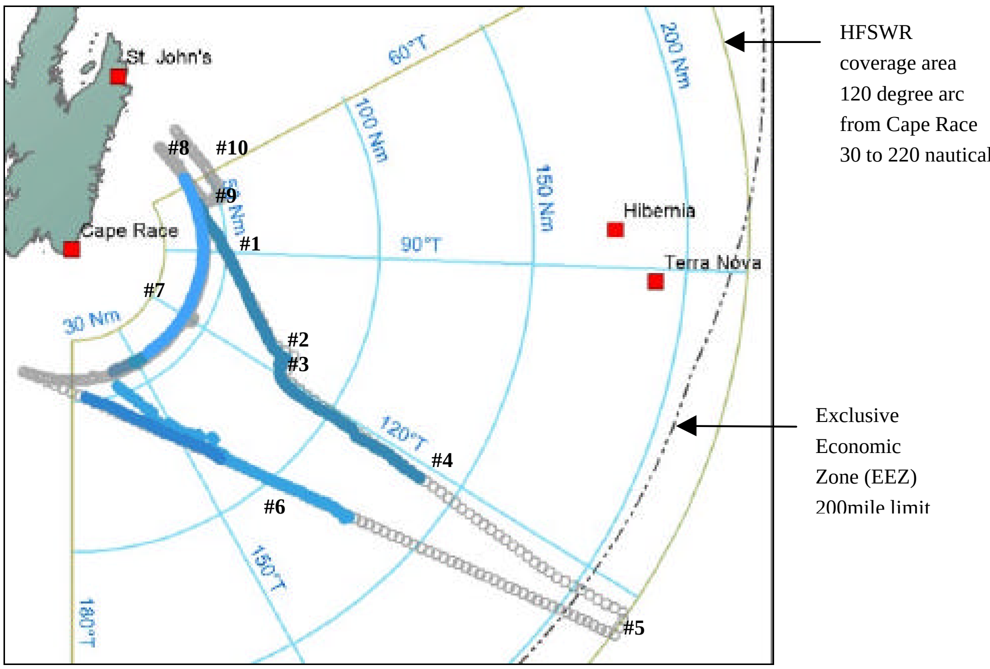

FIGURE 2. HFSWR OPVAL TRIAL. CONTROLLED SHIP TRACK (GREY CIRCLES) AND HFSWR TRACKS (BLUE).

HFSWR tracked the ship around the route using six different track identification numbers. HFSWR's maximum detection range suffered because of the environmental conditions during the trial (i.e. high levels of ionospheric and surface clutter), but when it was able to track the vessel, the system gave timely and accurate tracking information. On its own, HFSWR was able to detect and track the vessel during 53% of the controlled ship route (when operating inside the HFSWR coverage area) and when working with other RMP sensors, the composite track was increased to 78%.

* MERGEFORMAT During this OVPAL trial, HFSWR excelled in three of the seven MOPs, performing significantly better than the other data sources currently contributing to the RMP.

a. Underlined: Number of Reports. HFSWR provided 373 reports on the controlled ship over a 60-hour period, which was significantly higher than the other existing sensors.
b. Timeliness. HFSWR reported a new position every 4.3 minutes; and the data was received in the RMP within 5 minutes of detection. This was much better than other sources.
c. Uniqueness and Complementarity. The benefit added to the RMP by both the uniqueness and the complementarity of the HFSWR tracks was significant, improving the RMP by more that 100% when HFWR was added to the main RMP data source.

With respect to the remaining MOP, HFSWR provided value-added benefits that ranged from minimal (e.g. ‘Sensitivity’) to moderate (e.g. ‘Positional Accuracy’) improvement relative to existing RMP sensors.

3. FORCE PLANNING SCENARIOS BASED DECISION MAKING

The evaluation above provides a valuable assessment of the overall utility of the HFSWR system to the generation of the RMP, but it does not provide the decision maker with a context in which to make a decision whether to utilize the capability or to further develop it. The authors are proposing that evaluating the benefit provided by the system in recognized scenarios can provide this “real world” context.

The Vice Chief of the Defence Staff (VCDS) has published a comprehensive set of eleven Force Planning Scenarios (FPS) for strategic planning. This section of the report introduces the experimental technique devised by the authors that compares the utility of HFSWR against the most relevant FPS relating to Intelligence Surveillance and Reconnaissance (ISR). This approach was developed to address the lack of a fully developed Operational Statement of Requirement for ISR, which is one of the major challenges of this OPVAL process.

3.1 METHODOLOGY

The objective of the proposed methodology is to provide a link between the relevant aspects of the scenarios and the performance measures. The authors believe that this methodology can be used for any ISR system being evaluated for inclusion into the RMP.

The process is outlined in the Steps described below. The results are summarized for the HFSWR system evaluation in Table II, III, and IV.

Step1: Select the scenarios for which the sensor system is potentially relevant (i.e. scenarios that have a Canadian ISR flavour). (Column 1 of Table II)

Step2: Produce maritime vignettes (scripted events) that best represent each ISR scenario that would involve the sensor under consideration. (Column 2 of Table II)

Step 3: Determine the objectives of ISR for each scenario/vignette. (Column 3 of Table II)

Step 4: Identify five value-added benefits for each scenario that best match the objectives of Table II (Column 2 of Table III).

Step 5: Score the benefits using the method described in Section 3.2 while considering the OPVAL trial results. (Column 3 of Table IV).

Step 6: Provide a concise justification of the scores provided (Column 4 of Table IV).

The first three steps require interaction and collaboration with the stakeholders to ensure the accuracy of any underlying assumptions and to gain their acceptance of this methodology. For this OPVAL, four VCDS scenarios were selected that require significant ISR capability: (Search and Rescue (SAR), Surveillance, National Sovereignty, and Defence of North America). As these scenarios are too general in nature to provide a straightforward evaluation of the sensor system; maritime vignettes were produced for each of the four ISR scenarios and a set of ISR objectives was established for each vignette. The objectives provide a means to evaluate the sensor system in the context of the scenario/vignette. Table II illustrates the results of Steps 1, 2 and 3 for the HFSWR OPVAL.

TABLE II. MARITIME ISR SCENARIOS & OBJECTIVES

ISR FPS	Maritime Vignettes	ISR Objectives
Search and Rescue (SAR)	Initiated by distress signal – general location of search area provided	• Identify SAR vessel • Establish accurate datum position and time • Track SAR vessel and direct rescuing unit
	SAR vessel has been reported missing with a route but no specific location provided	• Define problem and reduce search area • Develop the profile of vessel (capabilities and intentions) • Establish an Area of Probability (AOP) • Establish track history to aid in search
Surveillance Contraband (All smuggling– drugs, people etc)	Identity of smuggling vessel, the departure port, and time of departure is known as well as the general destination of contraband carrying ship.	• Establish AOP • Establish contact box (high confidence that Vessel of Interest (VOI) is inside) • Reduce ambiguity by disregarding vessels on the basis of Course, speed, and origin • Maintain a track on VOI
	Intelligence provides description of contraband activity but no identification or route plan	• Intel focus – devise surveillance plan & AOP • Identify suspicious activity
Pollution	A pollution slick has been sighted but no ID of polluter	• Establish track history to pollution site • Collect evidence, report to authorities

National Sovereignty	Monitoring illegal fishing activities inside EEZ in vicinity of the Nose and Tail of the Bank	• Detect presence and level of activity inside EEZ • Develop profile of VOI (capabilities and intentions)
Defence of North America	Hostile act has been committed; prosecution of attacker is conducted after the fact	• Obtain/maintain a track on VOI • Collect evidence and report to responding unit
	On-going incident (hostage etc)	• Establish an AOI and report to authorities • Obtain and maintain situational awareness • Identify combatants/non-combatants
	Attempt to prevent extremist activity with Intel, no ID of hostile forces	• Define the problem (W5 + How) • Establish profile of vessel (capabilities and intentions, etc.) & AOP • Identify combattants / non-combattants
	Operational support to a Naval/Joint operation	• Provide situation awareness outside of ship/organic air assets sensor range

3.2 SCORING TECHNIQUE [1]

This scoring technique was developed to quantify the potential value-added benefits that HFSWR could bring to the RMP. From the assessment made on the HFSWR system, it is possible to identify the system's key strengths. To rate these and analyze them against the ISR scenarios requires choosing a suitable scoring mechanism.

Assigning an appropriate score to each attribute of a system is not an exact science and it is a challenging task. Many researchers have written about the inherent difficulty in capturing the decision making process by weighting attributes and creating scoring systems. Most admit that there is a level of subjectivity that must be injected into the process ([Keeney and Raiffa, 1976] [Zeleny, 1982]). Nevertheless, the essence of a scoring technique is to capture the importance/value of each attribute of a system and generate a score, index or rating scale that will assist the decision maker in understanding the value or benefit of any grouping of attributes.

For the purpose of this scenario-based technique, it was important to choose a scoring system that would capture what was observed during the OPVAL trial and condense this information down to one score that could be applied to each ISR scenario.

Referring to the MOP analysis in Section 2.2, HFSWR exhibited a significant improvement over the existing systems in the RMP for three measures and moderate improvement or less for the remaining four measures. In order to capture these observations, the authors chose to adopt a scoring system for each objective in the selected ISR scenarios. For each objective, HFSWR was assessed, based on the analysis of its performance in the trials, according to Table III.

---

[1] The authors would like to thank Mr. Ed Emond (DND-CORA/CORT) for his invaluable contribution to the development of this scoring technique.

TABLE III. SCORING METHOD

Score	Substantiation
0.0	HFSWR demonstrated *no* improvement to the RMP
0.1	HFSWR demonstrated a *slight to moderate* improvement
1.0	HFSWR demonstrated a *significant* improvement to the RMP (ie. 'a quantum leap' above all other existing systems)

This scoring method had several favorable qualities:

a. it summarizes the value of *significant* contributions by HFSWR and contrasts them with respect to areas of *slight* to *moderate* improvement and *no* improvement,
b. it presents an additive scoring system, where every scenario-based objectives are considered,
c. it provides a single score for HFSWR for each scenario, presenting to the decision makers a single number that is clear and easy to interpret, and
d. it provides a mechanism that can be used to compare other ISR systems against each other.

Note in Table IV, that five value-added benefits were determined for each scenario. This was purposely done so that the scores would add up to a maximum score of 5. This is not an essential step and it is possible to have any number of benefits per scenario. However, having a common scoring base simplifies the comparison and makes the results easier to interpret by the decision maker.

4. ISR FORCE PLANNING SCENARIO ANALYSIS

4.1 HFSWR FPS CONTRIBUTION

Applying our scoring system to the value-added benefits defined in Table III produced the results shown in Table IV. A score was determined for each value-added benefit based on the results from the trial. For example, consider the SAR scenario value-added benefit 'Reduce time need to assist' and its score of '1'. As there are no other near real-time sensors available for the generation of the RMP, the ability of the HFSWR system to provide near real-time updates represents a *significant improvement* over the RMP currently produced by other data sources.

During the trial the controlled vessel was detected out to a maximum range of 140 nautical mile (NM), short of the nominal 220 NM range limit, due to extremely high levels of ionospheric interference. Accordingly, on the basis of this single trial HFWSR system, it was assessed that HFSWR provided, at best, moderate improvement for the value-added benefit 'Detection of all vessels in an area' depending on the scenarios. For SAR and Defence of North America scenarios, the coverage area of interest is anywhere within in the HFSWR coverage area; therefore, the partial coverage provided by HFSWR was good enough to earn a 0.1 score.

However, for the Surveillance scenario that focuses on the monitoring of illegal foreign fishing at the Nose and Tail of the Grand Banks at the 200NM EEZ, the score received was '0' since HFSWR, on its own, provided no value beyond the 140 mile range.

TABLE IV HFSWR EVALUATION

ISR FPS	VALUE ADDED BENEFITS	HFSWR SCORE	REMARKS & ASSESSMENT OF IMPROVEMENT DUE TO HFSWR
SAR	Increase positional accuracy	0.1	Moderately better positional accuracy (1.5NM)
	Detect all vessels in an area	0.1	Detected controlled ship 53% of the time due to range shortfall (140NM vice 220NM)
	Reduce time need to assist	1	Only near-real time sensor, 4.3 min updates
	Identify vessel	0	Doesn't provide vessel ID
	Accessible data to third party	1	Unclassified, direct feed
SAR Capability improvement		**2.2**	
Surveillance	Detect all vessels in the AOP	0.1	Detected controlled ship 53% of the time due to range shortfall (140NMvice 220NM)
	Accurate continuous tracking	1	The best tracking sensor in the RMP
	Minimal use of tasked resources	1	Much improved RMP due to uniqueness and Complementarity with other sources
	Identify vessel	0	Doesn't provide vessel ID
	Correlate contacts in the area	.1	Good tracking helped reduce RMP ambiguity
Surveillance Improvement		**3.2**	
National Sovereignty Illegal Foreign Fishing (Nose / Tail of the Bank)	Detect violators	0	Could not detect vessels past 140NM
	Collect irrefutable evidence	0	Could not detect vessels past 140NM
	Minimal use of tasked resources	0	Could not detect vessels past 140NM
	Accessible data to third party	0	Unclass, direct feed but outside of range
	Direct authorities to location	0	Could not detect vessels past 140NM
Sovereignty Capability improvement		**0.0**	
Defence of North America	Covert tracking	0.1	HFSWR operating 24/7
	Tracking continuously	1	The best tracking sensor in the RMP
	Detect all vessels in an area	0.1	Detected controlled ship 53% of the time due to range shortfall (140NM vice 220NM)
	Accessible data to third party	1	Unclassified, direct feed
	Identify vessel	0	Doesn't provide vessel ID
Defence of North America improvement		**2.2**	

4.3 SUMMARY REMARKS

Comparing HFSWR within the ISR FPS context injects a real world component into the process. Based on the observations/results from Table IV, HFSWR provided improvement in three of the four ISR scenarios. The FPS showing the greatest improvement was Surveillance; achieving three major benefits over the status quo and two minor ones. The next most noticeable improvement was for FPS Defence of North America and SAR; where two major benefits and two minor benefits were noted. The FPS for National Sovereignty (illegal foreign fishing), however, did not receive additional benefit from using HFSWR due to its inability to track vessels at the 200NM EEZ.

These scorings are based on a single three-day trial. Extremely high levels of ionospheric interference characterized the trial and the high sea states produced high levels of surface clutter. Results from more extensive trials at different times of the year, different weather conditions and vessels with significantly different radar cross section areas will undoubtedly produce different results that could alter the scoring. Notwithstanding, it would be an easy and straightforward process to re-score HFSWR.

The strength of this scenario based assessment of sensors is that it compares performance against actual tasks and roles outlined in the Defence White Paper and provides a quantifiable performance score that can be easily communicated to decision makers. The weaknesses of this approach lie in its subjectivity. To mitigate these weaknesses, it is strongly recommended that stakeholders are involved early to determine and prioritize the value-added benefits and provide guidance in devising a scoring system. Once this is done, the authors believe that this approach could be useful and easily applied when comparing a broader range of surveillance sensors.

5. CONCLUSIONS

In this paper we have proposed a methodology for evaluating the value-added benefit of a surveillance system to the generation of the recognized maritime picture. The approach provides a direct link between the more technical aspects of an OPVAL and the decision maker’s need for a straightforward measure of utility through the use of the Canadian Forces FPS. These scenarios are representative of the generic types of missions that the CF may be called upon to perform. Basing evaluation decisions on these scenarios authenticates the evaluation process and improves the odds that the right sensor is acquired for the right reasons. The approach has been applied to data obtained during trials of the HFSWR system located off the east coast Newfoundland, Canada.

The approach consists of determining FPS that relate to the operational role of the sensor being evaluated; developing representative vignettes for each of the FPS; tailoring MOP for each vignette; matching trial data to the vignettes; and analyzing, the results were against quantifiable measures of value. The benefits and drawbacks of this approach in assessing sensors in the context of ISR have been demonstrated. This is done using the results of trial data for HFSWR and other surveillance sensors that were detecting targets within the HFSWR coverage area. The observed tracks were matched to a specific vignette profile and all the sensor data was then assessed for their contribution to the RMP, both individually and collectively as fused data, given the requirements for the FPS vignette.

The primary contribution of this paper is to demonstrate the feasibility of relating the results from an operational evaluation to the Force Planning Scenarios in a quantifiable fashion. The main conclusion of the paper is that the vignettes present the capabilities of the sensors to the decision makers in a logical and intuitive way and they give a context to the results of the analysis that becomes easy to communicate to the larger audience.

6. REFERENCES

[Dickinson *et al.*, 1997] Dickinson, R.G., Martel, S., Jesion, A. (1997), *Measures of Performance and Effectiveness for Surface Surveillance*, Operational Research Division Project Report, Department of National Defence, Ottawa, Canada

[National Defence, 1994] National Defence (1994), *1994 Defence White Paper*, Department of National Defence, Ottawa Canada

[Moutray and Ponsford, 1997] Moutray, R.E., Ponsford, A.M., *Integrated Maritime Surveillance for the Grand Banks*, Oceans ’97 MTS/IEEE. Conference Proceedings, p981-6 vol.2 1997, Halifax, Canada

[Lefebvre *et al*, 2001] Lefebvre, E., Simard, M., Helleur C. (2001). A Multisource Information Adaptive Fuzzy Logic Correlator for Recognized Maritime Picture, *Applied informatics 2001 - Symposium 1 Artificial Intelligence and Applications*, Innsbruck, Austria.

[Simard *et al.*, 2000] Simard, M., Lefebvre, E, Helleur, C. (2000). *Multisource Information Fusion Applied to Ship Identification for the Recognised Maritime Picture*, SPIE Conference, Orlando

[Keeney and Raiffa, 1976] Keeney, R.L., Raiffa, H. (1976) *Decisions with Multiple Objectives: Preferences and Value Tradeoffs*, Wiley & Sons, New York, USA.

[Zeleny, 1982] Zeleny, M. (1982), *Multiple Criteria Decision Making*, McGraw-Hill, New York, USA.